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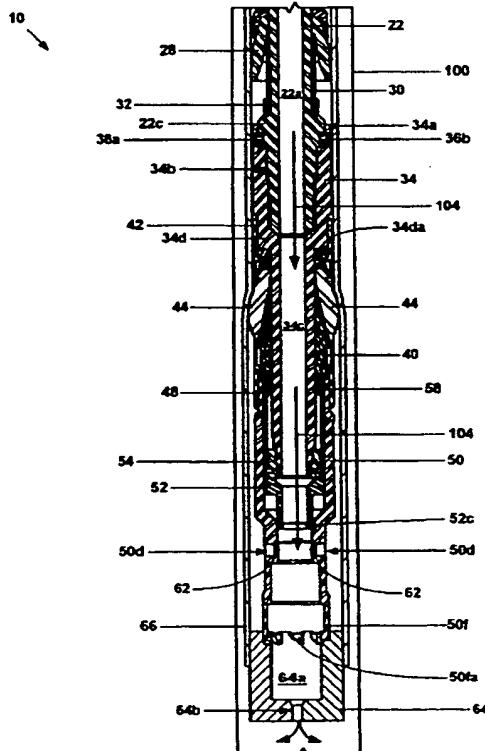
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(54) Title: COLLAPSIBLE EXPANSION CONE



(57) Abstract: An apparatus for radially expanding and plastically deforming an expandable tubular member (66) includes a collapsible expansion cone (44).

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,842,082 A (SPRINGER) 27 June 1989 (27.06.1989), see entire document, especially Figs. 27-30.	20, 23
A	US 6,491,108 B1 (SLUP et al.) 10 December 2002 (10.12.2002), see entire document.	20-27
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
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Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703)305-3230	Authorized officer Zakiya N. Walker <i>[Signature]</i> Telephone No. (703) 308-2168	

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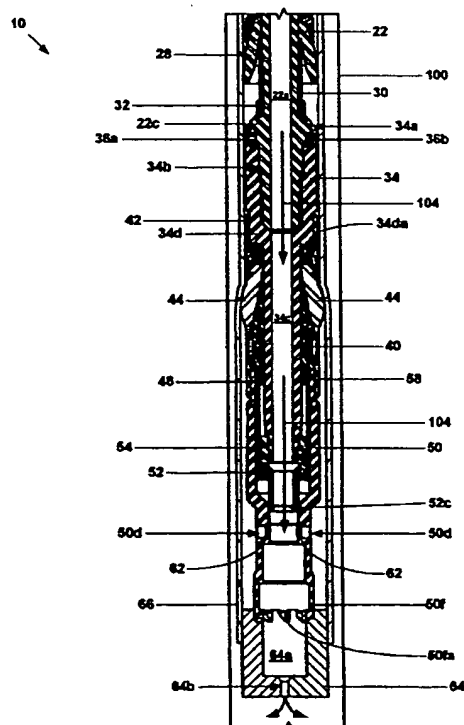
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[Continued on next page]

(54) Title: **COLLAPSIBLE EXPANSION CONE**

(57) Abstract: An apparatus for radially expanding and
plastically deforming an expandable tubular member (66)
includes a collapsible expansion cone (44).



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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

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- with amended claims

AMENDED CLAIMS

**[Received by the International Bureau on 27 June 2004 (27.07.2004);
original claims 1-21 and 23-32 unchanged,
original claim 22 replaced by amended claim 22, claims 33-70 added]**

a lower cam assembly coupled to the lower tubular support member comprising:

a tubular base coupled to the lower tubular support member; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments;

wherein the cam arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and

a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment pivotally coupled to the internal flange of the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly; and wherein the apparatus further comprises:

means for releasably coupling the upper tubular support member to the lower tubular support member; and

means for limiting movement of the upper tubular support member relative to the lower tubular support member.

22. The apparatus of claim 21, further comprising:

means for pivoting the upper expansion cone segments; and

means for pivoting the lower expansion cone segments.

23. The apparatus of claim 20, further comprising:

means for pulling the collapsible expansion cone through the expandable tubular member.

24. A collapsible expansion cone, comprising:

an upper cam assembly comprising:

a tubular base; and

a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;

a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly;

a lower cam assembly comprising:

a tubular base; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the

member using the cup seals.

31. (Original) The method of claim 28, wherein the tubular support member comprises an upper tubular support member and a lower tubular support member; and wherein collapsing the collapsible expansion cone comprises displacing the upper tubular member relative to the lower tubular support member.

32. (Original) The method of claim 31, wherein the collapsible expansion cone comprises: an upper cam assembly comprising:

- a tubular base; and

- a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;

- a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the upper tubular support member;

- a lower cam assembly comprising:

 - a tubular base; and

 - a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments;

 - wherein the cam arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and

- a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment pivotally coupled to the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly.

33. (New) A method of radially expanding and plastically deforming an expandable tubular member, comprising:

- supporting the expandable tubular member using a tubular support member and a collapsible expansion device;

- injecting a fluidic material into the tubular support member;

- sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member.

displacing the collapsible expansion device relative to the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member;

sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member; and

collapsing the collapsible expansion device when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member.

34. (New) The method of claim 33, further comprising:

pulling the collapsible expansion device through the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member.

35. (New) The method of claim 34, wherein pulling the collapsible expansion device through the expandable tubular member comprises:

coupling one or more cup seals to the tubular support member above the collapsible expansion device;

pressuring the interior of the expandable tubular member below the cup seals; and

pulling the collapsible expansion device through the expandable tubular member using the cup seals.

36. (New) The method of claim 33, wherein the tubular support member comprises an upper tubular support member and a lower tubular support member; and wherein collapsing the collapsible expansion device comprises displacing the upper tubular member relative to the lower tubular support member.

37. (New) A system for radially expanding and plastically deforming an expandable tubular member, comprising:

means for supporting the expandable tubular member using a tubular support member and a collapsible expansion device;

means for injecting a fluidic material into the tubular support member;

- means for sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member;
- means for displacing the collapsible expansion device relative to the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member;
- means for sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member; and
- means for collapsing the collapsible expansion device when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member.

38. (New) The system of claim 37, further comprising:

- means for pulling the collapsible expansion device through the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member.

39. (New) The system of claim 38, wherein means for pulling the collapsible expansion device through the expandable tubular member comprises:

- means for coupling one or more cup seals to the tubular support member above the collapsible expansion device;
- means for pressuring the interior of the expandable tubular member below the cup seals; and
- means for pulling the collapsible expansion device through the expandable tubular member using the cup seals.

40. (New) The system of claim 37, wherein the tubular support member comprises an upper tubular support member and a lower tubular support member; and wherein means for collapsing the collapsible expansion device comprises means for displacing the upper tubular member relative to the lower tubular support member.

41. (New) A method of radially expanding and plastically deforming a tubular member, comprising:

pressurizing an interior portion of the tubular member, and
displacing an expansion device through the pressurized interior portion of the tubular member.

42. (New) The method of claim 41, wherein pressurizing an interior portion of the tubular member comprises pressurizing an annular interior portion of the tubular member.

43. (New) The method of claim 41, wherein displacing an expansion device through the pressurized interior portion of the tubular member comprises pulling the expansion device through the pressurized interior portion of the tubular member.

44. (New) The method of claim 43, wherein pulling the expansion device through the pressurized interior portion of the tubular member comprises using the operating pressure of the pressurized interior portion of the tubular member to pull the expansion device through the pressurized interior portion of the tubular member.

45. (New) A system for radially expanding and plastically deforming a tubular member, comprising:
means for pressurizing an interior portion of the tubular member; and
means for displacing an expansion device through the pressurized interior portion of the tubular member.

46. (New) The system of claim 45, wherein means for pressurizing an interior portion of the tubular member comprises means for pressurizing an annular interior portion of the tubular member.

47. (New) The system of claim 45, wherein means for displacing an expansion device through the pressurized interior portion of the tubular member comprises means for pulling the expansion device through the pressurized interior portion of the tubular member.

48. (New) The system of claim 47, wherein means for pulling the expansion device through the pressurized interior portion of the tubular member comprises means for using the operating pressure of the pressurized interior portion of the tubular member to pull the expansion device through the pressurized interior portion of the tubular member.

49. (New) An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

an upper tubular support member;

one or more cup seals coupled to the exterior surface of the upper tubular support member for sealing an interface between the upper tubular support member and the expandable tubular member;

an upper cam assembly coupled to the upper tubular support member comprising:

a tubular base coupled to the upper tubular support member; and

a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining a camming surface;

a plurality of upper expansion segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the tubular support member;

a lower tubular support member; and

a lower cam assembly coupled to the lower tubular support member comprising:

a tubular base coupled to the lower tubular support member; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining a camming surface that mates with a corresponding one of the upper expansion segments;

wherein the cam arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and

a plurality of lower expansion segments interleaved with cam arms of the lower cam assembly, each lower expansion segment pivotally coupled to the lower tubular support member and mating with the camming surface of a corresponding one of the cam arms of the upper cam assembly;

wherein the lower expansion segments interleave and overlap the upper expansion segments; and

wherein the upper and lower expansion segments together define an external surface for plastically deforming and radially expanding the expandable tubular member.

50. (New) The apparatus of claim 49, wherein the upper tubular support member comprises:

a safety collar;

a torque plate coupled to the safety collar comprising a plurality of circumferentially spaced apart meshing teeth at an end;
an upper mandrel comprising a plurality of circumferentially spaced apart meshing teeth at one end for engaging the meshing teeth of the torque plate and an external flange at another end; and
a lower mandrel coupled to the external flange of the upper mandrel comprising an external flange comprising a plurality of circumferentially spaced apart meshing teeth.

51. (New) The apparatus of claim 50, wherein the tubular base of the upper cam assembly comprises a plurality of circumferentially spaced apart meshing teeth for engaging the meshing teeth of the external flange of the lower mandrel.

52. (New) The apparatus of claim 50, further comprising:
a stop nut coupled to an end of the lower mandrel for limiting the movement of the lower tubular member relative to the lower mandrel.

53. (New) The apparatus of claim 50, further comprising:
locking dogs coupled to the lower mandrel.

54. (New) The apparatus of claim 49, wherein the lower tubular support member comprises:
a float shoe adapter comprising a plurality of circumferentially spaced apart meshing teeth at one end, an internal flange, and a torsional coupling at another end;
a lower retaining sleeve coupled to an end of the float shoe adapter comprising an internal flange for pivotally engaging the lower expansion segments; and
a retaining sleeve received within the float shoe adapter releasably coupled to the upper tubular support member.

55. (New) The apparatus of claim 54, wherein an end of the retaining sleeve abuts an end of the tubular base of the lower cam assembly.

56. (New) The apparatus of claim 54, wherein the tubular base of the lower cam assembly comprises a plurality of circumferentially spaced apart meshing teeth for engaging

the meshing teeth of the float shoe adaptor.

57. (New) The apparatus of claim 64, further comprising:

a float shoe releasably coupled to the torsional coupling of the float shoe adaptor;
and

an expandable tubular member coupled to the float shoe and supported by and
movably coupled to the upper and lower expansion segments.

58. (New) The apparatus of claim 49, further comprising:

one or more shear pins coupled between the upper tubular support member and the
lower tubular support member.

59. (New) The apparatus of claim 49, further comprising:

a stop member coupled to the upper tubular support member for limiting movement
of the upper tubular support member relative to the lower tubular support
member.

60. (New) The apparatus of claim 49, further comprising:

a float shoe releasably coupled to the lower tubular support member that defines a
valveable passage; and

an expandable tubular member coupled to the float shoe and supported by and
movably coupled to the upper and lower expansion segments.

61. (New) The apparatus of claim 49, wherein each upper expansion segment
comprises:

a portion defining a surface including a hinge groove for pivotally coupling the upper
expansion segment; and

wherein each lower expansion cone segment comprises:

a portion defining a surface including a hinge groove for pivotally coupling the
lower expansion segment to the lower tubular support member.

62. (New) The apparatus of claim 61, wherein each upper expansion segment is

tapered in the longitudinal direction; and wherein each lower expansion segment is tapered
in the longitudinal direction.

63. (New) A collapsible expansion device comprising:
- an upper tubular support member comprising an internal flange;
 - an upper cam assembly coupled to the upper tubular support member comprising:
 - a tubular base coupled to the upper support member; and
 - a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;
 - a plurality of upper expansion segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the internal flange of the upper tubular support member;
 - a lower tubular support member comprising an internal flange;
 - one or more frangible couplings for releasably coupling the upper and lower tubular support members;
 - a lower cam assembly coupled to the lower tubular support member comprising:
 - a tubular base coupled to the lower tubular support member; and
 - a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion segments;
 - wherein the cam arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and
 - a plurality of lower expansion segments interleaved with cam arms of the lower cam assembly, each lower expansion segment pivotally coupled to the internal flange of the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly;
 - wherein the lower expansion segments interleave and overlap the upper expansion segments; and
 - wherein the upper and lower expansion segments together define an external surface for plastically deforming and radially expanding the expandable tubular member.
64. (New) The assembly of claim 63, wherein each upper expansion segment comprises:
- a portion defining a surface including a hinge groove for pivotally coupling the upper

expansion segment to the upper tubular support; and
wherein each lower expansion segment comprises:
a portion defining a surface including a hinge groove for pivotally
coupling the lower expansion segment to the lower tubular support
member.

65. (New) The assembly of claim 63, wherein each upper expansion segment is tapered in the longitudinal direction; and wherein each lower expansion segment is tapered in the longitudinal direction.

66. (New) An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

- a tubular support member;
- a collapsible expansion device coupled to the tubular support member;
- an expandable tubular member coupled to the collapsible expansion device;
- means for displacing the collapsible expansion device relative to the expandable tubular member; and
- means for collapsing the expansion device.

67. (New) The apparatus of claim 66, wherein the tubular support member comprises an upper tubular support member comprising an internal flange and a lower tubular support member comprising an internal flange; wherein the expansion device comprises:

- an upper cam assembly coupled to the upper tubular support member comprising:
 - a tubular base coupled to the upper support member; and
 - a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;
- a plurality of upper expansion segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the internal flange of the upper tubular support member;
- a lower cam assembly coupled to the lower tubular support member comprising:
 - a tubular base coupled to the lower tubular support member; and
 - a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper

expansion segments;
wherein the cam arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and
a plurality of lower expansion segments interleaved with cam arms of the lower cam assembly, each lower expansion segment pivotally coupled to the internal flange of the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly;
and wherein the apparatus further comprises:
means for releasably coupling the upper tubular support member to the lower tubular support member; and
means for limiting movement of the upper tubular support member relative to the lower tubular support member.

68. (New) The apparatus of claim 67, further comprising:
means for pivoting the upper expansion segments; and
means for pivoting the lower expansion segments.

69. (New) The apparatus of claim 66, further comprising:
means for pulling the collapsible expansion device through the expandable tubular member.

70. (New) A collapsible expansion device, comprising:
an upper cam assembly comprising:
a tubular base; and
a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;
a plurality of upper expansion segments interleaved with the cam arms of the upper cam assembly;
a lower cam assembly comprising:
a tubular base; and
a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion segments;

wherein the cam arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly;
a plurality of lower expansion segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly;
means for moving the upper cam assembly away from the lower expansion segments; and
means for moving the lower cam assembly away from the upper expansion segments.

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